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EDITORIAL NOTES

SULPHUR REMOVAL

THERE has been a colossal amount of talk about the desirability of removing organic sulphur compounds from town gas, the while organic sulphur compounds are for the most part being freely distributed. We know the times are inopportune for adding to the gas engineer's many burdens, for the shouldering of which he is all too frequently paid scantily, and we realize that the gap between desire and practice cannot under present conditions of labour and materials be bridged; but we do look forward to what we may term a "must" clause about organic sulphur removal as soon after the war as possible. Technically, it would seem, there is nothing to stand in the way, and economically there should be no barrier. And looking to the future we were glad to publish last month a contribution on the subject by Dr. Griffith and Mr. Plant, of the Gas Light and Coke Company, in which they gave a clear and full account of recent development work—an account altogether heartening. The unit dealt with operates on the catalytic process, and it has been at work since the beginning of 1938. It has proved itself, and the experience gained and so freely put at the disposal of others will be helpful and does in fact call for future action.

The plant is a "pilot" plant only in the sense that it has led the way. Actually it has a capacity of 1,500,000 cu.ft. of gas (8,500 therms) a day. Teething troubles were experienced, but quickly remedied, thanks no doubt largely to the careful experimental work which preceded erection of the plant. In the Paper, working costs are shown for the whole process at pre-war prices. the cost per therm given being 0.135d.—a small figure of expenditure to be able to send out gas containing practically no sulphur, and thereby opening up new fields of use quite apart from enormous saving in appliance maintenance costs. The plant described is at the Harrow Works of the Gas Light and Coke Company. It is positioned before the benzole plant, in which active charcoal is used as absorbent. Improvement in the life of the charcoal and in the sulphur content of the benzole has resulted from treatment of the gas in the catalytic plant; and the Authors suggest that this is the best arrangement on any works with a similar benzole extraction plant, though the alternative arrangement is "permissible." When oil washing is used for benzole recovery, the reverse order should be employed.

The process, then, is a proved proposition, and it is not a question of size of plant. Large works or small works could apply it; the proposition is, in brief, offered on a plate, and we hope that, post-war, there will be less talk about sulphur removal and more action. As we have said before, maybe *ad nauseam*, the present sulphur content in town gas, generally speaking, is a very poor business indeed. The consuming public have a right to expect something better; it is a legitimate demand which should be met. If we ourselves want to take sulphur into our system we wish to do so in our own time and in our own way, and not just when the gas undertaking orders it, and not necessarily in the doses it forces upon us.

In calling attention to the description of the Harrow plant which has appeared in our pages we would mention that where special demands exist for a gas with a low content of total sulphur, as, for example, in the production of special furnace atmospheres, the catalytic process has proved very satisfactory for small-scale operation. Some 40 units of the type have been at work in various parts of the country for periods up to four years—and without any trouble.

NOW AND TO-MORROW

IT is anticipated that some 4,000,000 new homes will be required to be built and equipped in the ten years or so after the end of the war, and if they are designed for a life as short as 50 years the money spent on fuel used in them will exceed the cost of the houses themselves. We are not so much concerned with the exactitude of the figures as with the point that the fuel-using equipment in the houses is in truth a matter of the utmost importance to the occupier, and that to satisfy properly future needs present co-operation between the Gas Industry and architect and builder and housing authority is not merely desirable, but essential. Hence our interest in the work being done by the British Commercial Gas Association in fostering this co-operation and providing means to make it effective. The Association is in fact providing a solid background of information, a background the more potential because it is educative rather than propaganda as commonly understood. We refer to publications such as the recently issued "Post-War Homes," which includes descriptions of several model houses and kitchens, and indicates to what good advantage gas fits into the projected plans. This booklet, which strikes us as being fresh, informative, and much to the point, is taken as an example only of means and method; and we think the idea behind it and other similar services to be thoroughly sound. Perhaps we should add that the value of this type of "service" is directly proportional to the extent of its use—in other words, to the action as well as the interest taken by individual gas undertakings in their areas of supply—and we would emphasize that the educative literature being produced is the reverse of the "glance and throw-away" type.

Of course there is obvious purpose behind all this work, just as there is obvious purpose behind all advertising, which is to extend the sales of the goods or services advertised. It may or may not matter much whether we use Smith's powder or Jones's paste for cleaning our teeth, in spite of the opinions held respectively by Smith and Jones. But there is something additional about the "publicizing" of gas, which can, in affording comfort, cleanliness, and convenience to the individual consumer, assist the national economy as a whole, and we believe that the publicity service of the Gas Industry can, in itself, be of direct and growing benefit to the community. We feel sure, too, that the educative tone and informative style of much of the B.C.G.A.'s publicity, restricted as this publicity is, form an appropriate basis in current circumstances and should be extended immediately opportunity offers. Not for a moment do we suggest that it should not be supplemented by other forms of propaganda, perhaps of a more striking or even blatant pattern, when we return to peacetime conditions. On the other hand we do think that the present line of activity of the B.C.G.A. in picture and in written and spoken word is the right one, and is no doubt preparing a firm foundation for future extended effort.

Dr. E. W. Smith

It would be as superfluous for us to "write-up" Dr. Smith on the occasion of his relinquishing his Directorships of the Woodall-Duckham Companies as it would be to publish his photograph just because he happened to be giving a public address, though this is a journalistic habit which dies hard even in these days of paper famine. Yet we cannot let pass entirely without comment an event so interesting to the Gas Industry. Dr. Smith's love of freedom—almost, we might

say, of adventure—is well enough known in the fuel industries, and the announcement in our Personal column this week will cause no undue surprise. The Companies with which he has been so long associated are held in universal esteem, and consequently, much as they no doubt regret the resignation of their Technical Director, it will be realized that they would never stand in the way of one who felt he could render higher public service elsewhere. From a recent conversation with Dr. Smith we gather the impression that he is "going campaigning" rather than that he has any set scheme in prospect, but no one who knows him will suspect that his present resignation portends a life of less activity, especially as he proclaims himself fighting fit at the present moment, and looks do not in the least belie him. He feels that his capacity for making himself generally useful will be enhanced by freedom from any ties of commercial interest, and we shall look forward to seeing in what directions his boundless energy leads him. In the meantime he has accepted, as we announced last week, a second year of office as President of the Institute of Fuel, which offers him scope, to begin with, for a very large measure of "public work."

An Encouraging Gesture

A most generous offer has been made by Imperial Chemical Industries, Ltd., to put into practical effect that liaison between industry and science which has of late been advocated so strongly in so many quarters. I.C.I. has offered Fellowships to nine universities selected on account of their size and metropolitan character, or because of their geographic relation to the main centres. Oxford, Cambridge, and London have been offered twelve fellowships each; Glasgow, Edinburgh, Liverpool, Manchester, and Birmingham, eight; and the University of Durham, four—a total of 80. The Fellowships will be of the average value of £600 per annum. The Directors of I.C.I. have described on broad lines the subjects in which the fellowships are to be held and the administration of the scheme rests wholly with the Universities, which will select and appoint the Fellows, subject only to such conditions as to duties and tenure as the Universities themselves impose. The purpose in instituting the scheme is to strengthen the general provision in the British Universities for scientific teaching and research, in the belief that academic and industrial research are interdependent and complementary, and that substantial advances in industry cannot be looked for without corresponding advances in academic science. The immediate objective should be the strengthening of University scientific departments in whatever way each University thinks to be best. No conditions whatever are attached by the Directors to the tenure of these Fellowships. The Fellows will be members of the University staffs and will be concerned only with the duties laid upon them by the Universities. Their primary work will lie in research. But they must also take some part in University teaching. It is intended not to relieve the Universities from the cost of maintaining any part of their normal work, but to enable them to add to what they already do. It is a most encouraging gesture, and we hope and believe it will have far-reaching effect. A policy of this character, together with a wise selection of men as regards both capabilities and tenure of office, should lead to the emergence of a body of men capable of taking high academic or industrial positions, thereby advancing academic and industrial research. The fellowships may be given in any of the basic or applied sciences, on which so many industries depend.

Personal

Dr. E. W. SMITH, C.B.E., has resigned his position as Technical Director to the Woodall-Duckham Vertical Retort & Oven Construction Company (1920), Ltd., and his other Directorships in the Woodall-Duckham Group of Companies, with which group he has been associated for over 24 years. It is understood that he proposes to devote himself to public work.

* * *

Mr. T. N. JENNINGS, Secretary of Radiation Ltd., Mr. F. A. HOOPER, Director of John Wright & Co., Ltd., and Mr. W. D. KING, Director of Richmonds Gas Stove Company, Ltd., have been elected to the Board of Radiation Ltd.

* * *

Mr. NORMAN DOBSON retired on July 31 from his position as London Manager of Messrs. R. & J. Dempster, Ltd. For more than 26 years he has been in charge of their London office, and is well known to a large circle of friends in the Gas Industry. Entering the Industry with Messrs. Drake's, Ltd., in Halifax, Mr. Dobson afterwards joined Messrs. Cockey's at Frome, and in 1911 Messrs. Dempster, with whom he has remained until his retirement.

Mr. H. C. ARMITT, who has been associated with Mr. Dobson for a number of years, will still be available to deal with any points requiring the attention of the firm's London Office at 34, Victoria Street.

The Stoke-on-Trent Gas Committee has accepted the resignation of Mr. J. WARRILOW, Assistant Manager, who is retiring on Sept. 30. The Committee recorded appreciation of Mr. Warrilow's service during the past 60 years.

* * *

Friends of Lt.-Col. T. C. WHIMSTER, who represented the Parkinson Stove Company, Ltd., in the North-Eastern Counties, will be interested to know that a postcard has just been received from him dated Sept. 14, 1943, stating that he is in fair health, and conveying best wishes to his friends in the Gas Industry. Lt.-Col. Whimster is a prisoner of war in Japanese hands, and his postcard was sent from a P.O.W. Camp at Kushing, Borneo.

Obituary

The death in action in France has occurred of Major D. W. I. SOUTAR, of the Gordon Highlanders. Major Soutar was the eldest son of Mr. C. A. Soutar, Managing Director of Messrs. William Coward & Co., Ltd., Agents for Overseas Gas Undertakings, and was, when he joined the Army in 1939, on the staff of the Gas Light and Coke Company.

Letters to the Editor

Gas Staff Organization

DEAR SIR,—In your issue of July 5, p. 27, you published a letter headed "Gas Staff Organization" from the Control Committee of Gas Staff Associations, per Mr. E. W. Munn. The matter contained in the letter is of interest to the staff of this Company, which has had an Officials' Guild since 1920, the objects of which are as follows :

(*a*) To promote good fellowship and intercourse among its members. To cultivate efficiency and good conduct and loyal service to the public and one another.

(*b*) To co-operate where desirable—and affiliate where suitable—with other Guilds and Associations of Gas Officials and other Guilds and Associations comprising Public Officials.

(*c*) To improve the conditions and protect the interest of its members.

(*d*) To obtain and maintain reasonable hours of duty, scales of salaries, and other conditions.

I may add that the Management of the Company meet the representatives of the Guild in a friendly manner, giving an indication that they recognize the mutual value of such an organization,

I am inclined to agree with Mr. Munn in his statement that no general support would be found for creating a Trade Union of Gas Staffs, but feel that some sort of co-operation might be brought into being of a national character.

Newcastle-upon-Tyne and Gateshead Gas Company's Officials' Guild.
30, *Grainger Street*,
Newcastle-upon-Tyne 1.
July 26, 1944.

Yours faithfully,
J. E. PARKER,
President.

A Strange Investigation

DEAR SIR,—A woman has recently visited a number of houses in a town in the South-Eastern Region to make enquiries about "fuel allocations." Among the numerous questions asked, the replies to which she entered on one of a bundle of forms, were:

(1) Number of rooms in house.
(2) Number of occupants.
(3) Occupation of husband.
(4) Types of fuels used.
(5) Stock of fuel this time last year.
(6) Stock (which she inspected) of fuel to-day.

The Regional Office of the Ministry of Fuel and Power and the Local Fuel Officers having disclaimed any knowledge whatever of this investigation, the Police made extensive enquiries and took statements. It was then divulged that the Ministry was responsible for the investigation, which it had apparently initiated without any intimation to those directly concerned with fuel control and distribution or co-operation with those responsible for public security.

All the information sought is already recorded in, or could be readily obtained by, local fuel offices. It would be interesting, therefore, to know what purpose this special investigation is intended to serve, especially in a defence and evacuation area. It suggests a gross misuse of man-power, at a critical stage of the war, by a Ministry which has been unable to ensure that the fuel industries have sufficient personnel to carry on their essential work.

Further, the Ministry might think fit to say by what authority their investigators, in the absence of an invitation, enter upon premises and inspect fuel stocks without a search warrant signed by a magistrate.

Yours faithfully,
"VIGILANTIS."

The fact that goods made of raw materials in short supply owing to war conditions are advertised in the "Journal" should not be taken as an indication that they are necessarily available for export.

Model Kitchen at Reigate

"Thermcroft—the Kitchen of the Future" will be opened by the Mayor of Reigate, Alderman A. Windsor-Spice, Chairman of the Mid-Surrey Joint Planning Committee, behind 23, Church Street, Reigate, to-day, in the presence of a representative gathering of officials and others concerned with post-war housing.

"Thermcroft" has been devised as a contribution towards post-war housing and to secure the practical views of the public on kitchen planning, to facilitate which visitors are being invited to complete a questionnaire the replies to which should prove of considerable value. The exhibition is particularly opportune, having regard to the recent publication of the Report of the Design of Dwellings Sub-Committee of the Central Housing Advisory Committee appointed by the Minister of Health (see last week's "JOURNAL.")

Housed in an attractive building, "Thermcroft" comprises a fully working kitchen, with separate laundry section and a living room with dining recess. Planned to minimize labour and ensure cleanliness, the interior is brightly decorated and well lit, extensive use being made of glass for working surfaces, walls, and cupboard doors. The all-enamel appliances and the kitchen equipment are built-in and flush, with a common working height for the food preparation table, eye-level, table-top cooker, and double stainless steel sink with draining boards, and hot and cold water mixer.

Included are a built-in refrigerator, radio, telephone, and a glass fronted cupboard, alongside the stable-type back door, containing the gas and electricity meters. There are numerous spacious cupboards and racks, many being glass fronted, for food, crockery, and utensils, and a vegetable cabinet containing wire trays and fitted with a roller front. A separate low level sink is provided, in which a bucket can be filled with hot and cold water.

A new type, all-purpose, slow-combustion solid fuel stove (which may be used open or closed) in the living room, heats that room and the house radiators and provides all the hot water required in the kitchen, laundry, bathroom, and wash basins. A multipoint gas water heater takes the place of the stove when the latter is not in use.

All pipes, flues and ventilation are contained in a centralized and accessible duct, to minimize fuel consumption and reduce the cost of installation and maintenance and to avoid frozen pipes. The adequate ventilation provided in the kitchen and laundry section ensures comfortable working conditions and contributes to the elimination of condensation and the smell of cooking.

The separate laundry section is fully equipped with a double washer having a hot and cold water mixer, wringer, drying cabinet, clothes cupboard, ironing board, iron and broom cupboard. If not required as a laundry this section could be used as a dining recess, utility room, or store and, if desired, laundry provision made in the kitchen.

"Thermcroft" will be open daily to the public from 10 a.m. to 8 p.m. throughout August. Special or party visits from any district will be arranged at any time, particularly for organizations or persons interested in post-war planning, housing, architecture, building, domestic economy, social service, and the like and for members of the Forces and Civil Defence Services, women being especially welcome.

Members of the Gas Industry are cordially invited to visit "Thermcroft" and to obtain any further information required from the General Manager of the East Surrey Gas Company, 2, Chart Lane, Reigate. Telephone Reigate 2468.

Wales Juniors

The Annual General Meeting of the Wales and Monmouthshire Junior Gas Association was held at the offices of the Newport (Mon.) Gas Company on July 20. The Chair was taken by Mr. W. R. Branson owing to the inability of Mr. D. W. Rees, the President, to be present. Mr. J. F. Rust, Engineer of the Newport Gas Company, welcomed the Association.

The report of the Council was adopted on the proposition of Mr. S. D. Cooles, Barry, seconded by Mr. C. B. Church, Newport.

Mr. B. J. Bell, Cardiff, the Hon. Treasurer, presented the financial statement. He referred to the gesture of the Senior Association in making a grant to the Association. Without this matters would no doubt have been difficult. The Association had, however, benefited also under the affiliation with the Joint Council, particularly in the matter of delegates' expenses.

Mr. I. G. Jenkins, Cardiff, moved the adoption of the statement. Mr. A. H. Dyer, Newport, seconded.

The following officers were elected:

President.—W. R. Branson.

Senior Vice-President.—K. M. Ernest.

Junior Vice-President.—D. E. Wilkins, Swansea.

Hon. Treasurer.—B. J. Bell, Cardiff.

Hon. Librarian.—H. S. Bartlett, Cardiff.

Hon. Auditors.—T. Noall and C. H. Banham.

Hon. Secretary.—K. M. Ernest.

Council.—D. I. Rowlands, Caerphilly; A. H. Dyer, Newport; and S. D. Cooles, Barry.

Leeds "Homes" Exhibition

The final special day organized by the Gas Industry at the recent four weeks' "Homes of Tomorrow" Exhibition at Lewis's Store, Leeds—promoted by the *Yorkshire Evening News*—was Chairmen and Engineers' Day, when there was a large attendance of chairmen and members of gas committees and gas company directors, and engineers and managers, at the Gas Industry stand. The demonstration theatre was well filled to hear the welcome given by Alderman S. Kaye, Mayor-elect of Huddersfield, and Chairman of the Huddersfield Gas Committee, supported by Alderman Bretherick, Chairman of the Leeds Gas Committee.

After the closing of the Exhibition many expressions of appreciation were voiced as to the value the occasion had been as information to the public, and as helpful to all concerned. Mr. R. A. H. Livett, Leeds Housing Director, thought it had given valuable publicity to post-war housing matters and internal fittings. Mr. C. S. Shapley, Leeds Gas Engineer and General Manager, considered it had been informative to the public. It had shown the public many new types of appliances, and aroused interest from the Yorkshire coast to the Lancashire border.

1944 "Journal" Directory

Page 43. LIVERPOOL. W. S. Hubbard, *E.*, *vice* W. Fletcher, resigned.
„ 65. SLOUGH. J. H. Dyde (Uxbridge), *E. & M.*, *vice* H. Wilkinson.
„ 72. WALSALL. A. Allen (Partington), *E. & M.*
„ 88. KIRKCUDBRIGHT. J. H. Jamieson (Doune), *E. & M.*, *vice* A. G. Arnott.

Dividends

Bo'ness.—6%, free of tax, the normal rate of payment.

Brechin.—2s. 6d. per share and a bonus of 9d. per share, both less tax.

Cambridge.—For the half-year ended June 30, on the Ordinary Stocks: Consolidated Original Stock 5%; Consolidated "B" Stock 3½%; Consolidated "C" Stock 2½% (same as last year).

Gas Light and Coke—For the half-year ended June 30: on the 4% Consolidated Preference Stock at the rate of £4% per annum, less tax; on the 3¾% Redeemable Preference Stock, 1970, at the rate of £3 15s.% per annum, less tax; on the 3½% Maximum Stock at the rate of £3 10s.% per annum, less tax. The Directors have also declared a dividend for the same half-year on the Ordinary Stock at the rate of £5% per annum, less tax (£2 10s.% actual, less tax).

Montrose.—Final at the rate of 4¼%, less income tax, making a dividend of 8¼% for the year, plus bonus of 4d. per share, both less tax.

Romford.—Interim half-yearly on account of the year ending Dec. 31, 1944, subject to audit: On the 5½% Preference Stock, at the rate of 5½% per annum (2¾% actual). On the 4% Redeemable Preference Stock, at the rate of 4% per annum (2% actual). On the 3¾% Redeemable Preference Stock, at the rate of 3¾% per annum (1⅞% actual). On the Ordinary Stock, at the rate of 5% per annum (2½% actual).

Stirling.—Final of 9s. 2d. per share on the original capital and 10s. 9d. per share on the new Ordinary capital.

A **Meeting** of the non-statutory gas companies in Scotland—called at the instance of the Committee of Management of the National Gas Council—was held in the North British Station Hotel, Edinburgh. Mr. D. Fulton, Chairman of the Committee, presided. The meeting considered what, if any, evidence they might have to offer before the Committee of Enquiry set up by the Ministry of Fuel, which is to review the structure and organization of the Gas Industry in the United Kingdom. After discussion, it was agreed to appoint a small committee with a watching brief as to any special interests of these non-statutory gas companies, and to co-operate with the National Gas Council in presenting evidence to the Committee of Enquiry.

Cape Town and District Gas Light and Coke Company reports a net balance of revenue for the year ended Dec. 31, 1943, of £22,064, less £12,367 for debenture and general interest. Transfer of £7,000 to reserve for plant renewals leaves, with the balance brought in, £6,822 to be carried forward. Loans amounting to £7,800 were repaid during the year, and a remaining balance of loan of £9,000 is reducible by annual payments. In a statement issued to shareholders, Sir George Barstow, Chairman, reports that demands on output were so heavy that it was not practicable to shut down any part of the plant to enable renewals to be started. To relieve this situation a contract has been placed for additional producing plant, and fabrication under special priorities is proceeding. Following the ordinary meeting on Aug. 18 extraordinary meetings of members, preference, and ordinary shareholders will be asked to approve a scheme of arrangement to deal with accumulated arrears of preference dividend, involving the cancellation of the arrears accrued and unpaid from 1933 to 1943, and the issue of funding certificates to the nominal amount of £22,500, carrying 4½% interest per annum (cumulative) from Nov. 1, 1943, to the holders of preference capital in satisfaction of the cancellation.

(*Further news items will be found on p. 154*)

Boiler Water Treatment*

By R. P. DONNELLY, B.A., B.Sc., A.M.I.Chem.E.

(*Concluded from p. 116*)

As between lime-base exchange and lime-soda treatment, the latter is usually cheaper in first cost of plant. On the reagent costs they are about equal; for the quantities of lime required are identical, and salt, replacing soda ash, costs practically the same if a salt efficiency of 45% is operated in regeneration and the soda ash is used at 90% efficiency—salt costing 54s. and soda ash 123s. per ton.

From the technical point of view lime-base exchange treatment is entirely preferable as it gives a dead soft water of controlled alkalinity with latitude provided in the base exchange stage for any departure from adjustment in the lime treatment—*i.e.*, whatever goes into the base exchange stage, the emergent water is always soft. With lime-soda treatment this elasticity in control does not exist.

TABLE IV.—Spiractor Lime Pretreatment to Base Exchange Plant. (Analyses, p./100,000.)

	Raw water.	Exit spiractor.	Exit base exchange.
Calcium hardness	26.5	8.5	*Nil*
Magnesium hardness	3.5	3.5	,,
Alkalinity:			
Me.Orange	22.5	5.0	5.0
Phenolphthalein	*Nil*	0.5	0.5
Temporary hardness	22.5	5.0	Commercial.
Permanent hardness	7.5	7.5	Zero.
Total dissolved solids	43.0	21.0	21.0
pH	7.9	8.4	8.4

It is to be noted that 5.0 parts of temporary hardness leave the Spiractor plant. By increasing the dosage of lime the figure could be reduced to 3.0 with a corresponding increase in the phenolphthalein alkalinity.

Yet a further method of securing stabilization of lime pre-treated water consists in interposing before the base exchange stage a filter filled with, not sand, but carbonaceous zeolite. This acts, not only as a filter to remove matter carried in suspension, but also removes excess alkali if periodically treated with dilute mineral acid or even water saturated with carbonic acid. The filter in a sense acts in the same way as the addition of acid to the water; but it is self regulating in its dosage. The method is described in B.P. 484,494.

New Base Exchange Materials (6)

In the foregoing an efficiency of 45% was quoted for the regeneration of the base exchange unit. Such a salt efficiency can only be obtained by use of the newer base exchange materials, particularly the organolites or carbonaceous zeolites.

If the capacity of a base exchange material is defined as the number of grains of hardness which one cubic foot of the material will remove between regenerations, the salt efficiency can be defined as the ratio between the amount of salt chemically equivalent to the capacity produced and the amount of salt actually required to produce that capacity. The amount of salt chemically equivalent to 1,000 grains of $CaCO_3$ is 0.164 lb. The salt efficiency is then:

$$\text{Salt efficiency} = \frac{0.164}{\text{Salt actually required for 1,000 gr. capacity}}.$$

The regeneration of the base exchange material is to be looked upon as a normal physico-chemical equilibrium. It goes forward in the presence of excess sodium chloride and its degree of completeness is determined by the total quantity of brine used; the final stages of regeneration being attained with progressively diminishing efficiency, Table V.

Equally the full capacity of a regenerated material is not developed in exchange if there is an appreciable concentration of sodium chloride or other sodium or potassium salts in solution in the water; and this reduction of capacity is developed in a proportional manner.

$$2NaCl + CaZe = CaCl_2 + Na_2Ze.$$

The importance of this question of salt efficiency as governing the chemical costs of the process is important and, whereas a salt efficiency of 33.0% was an optimum for single regeneration a few years ago, the use of carbonaceous zeolites or organolites, of recent discovery, has advanced it to 50% for low capacity regeneration. It may be said, however, that if the zeolite bed is first regenerated with the spent brine from a previous regeneration a better effect is obtained with less salt in a final regeneration; the spent brine from this first wash is then stored for subsequent use as a first wash.

TABLE V.—Relationship Between Capacity and Salt Consumption of an Organolite.

Capacity per cu.ft. in grains.	Lb. NaCl per 1,000 gr. of $CaCO_3$.	Efficiency of regeneration %.
6,500	0.34	49.3
10,000	0.42	40.0
15,730	0.70	23.9
20,250	1.50	11.0
22,000	2.70	6.2

(The presence of sodium salts in the raw water reduces exchange capacity in the ratio of 1.25 gr. $CaCO_3$ for each 7 gr. of Na_2O per gallon.)

* A Paper to the London and Southern District Junior Gas Association.

Nature of Base Exchange Media

The discovery of base exchange began with the work of two English agricultural chemists, Thompson and Way, who, in 1845–52, showed that soils could hold and absorb lime and ammonium; this, they showed, arose from the displacement of sodium from certain alumino-silicates in the soil by these two bases. In 1858 Eichorn, a German, showed that the displacement could be reversed by washing with sodium chloride solution. The minerals which exhibited this exchange characteristic also, when heated in the blow-pipe, swelled or boiled up. Eichorn therefore gave them the general name of "zeolites" derived from the Greek and meaning a "boiling stone." In 1906 another German, Gans, produced an artificial zeolite, which was very slow in regenerating, and applied it to water softening. He called it "permutite" from the Latin "Permutare, to change."

Zeolite is, however, the name which has stuck, though the organic zeolites are better termed "organolites." The naturally occurring materials of the latter type are certain lignites.

The exchange property can be ascribed to the presence of an ionisable hydrogen in the amphoteric – OH hydroxyl grouping. In the alumino silicates the group is $Al\langle^{OH}_{O}{}^{H}$; with the organolites the active group is $>C-O-H$—*i.e.*, a phenolic or carboxylic group.

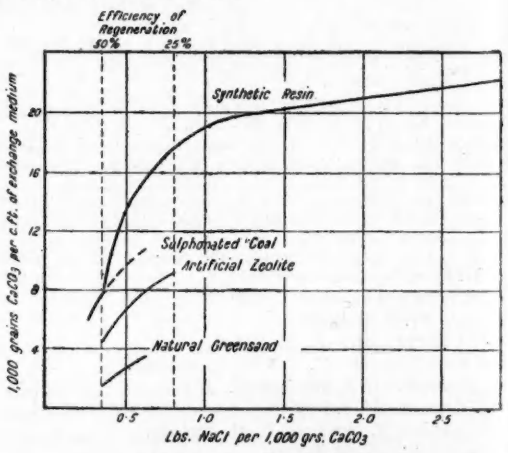
The base exchange property is exhibited in some degree by many clays and minerals. "Bentonite" clays have a considerable exchange capacity, although their physical characteristics render them unsuitable for use in water treatment. "Glauconite" or "Greensand" is, however, a mineral with suitable characteristics. Deep lying greensand strata account for the alkaline character shown by a number of London well waters. In America and Australia surface deposits of Greensand are found with a natural capacity of 2,000 grains which, when treated by peptising them with caustic soda, sodium silicate, &c., washing to remove clay, and roasting to 700°C., provide the greensand of commerce with a typical capacity of between 3–4,000 grains and—what is as important—a high rate of regeneration.

Artificial zeolites are in general prepared by mixing solutions of sodium aluminate with sodium silicate in such strengths that a gel is formed which is then dried off and broken up into sizes suitable for use. Their exchange capacity ranges up to 10,000 grains and, for some recent types, a high salt capacity is claimed. They tend to be very sensitive to variations in pH of the water in contact with them and, in this chemical way as well as in physical characteristics, are much less robust than greensands. Waters of high pH tend to dissolve them directly; while waters of low pH—that is, acid waters—exchange hydrion for sodium irreversibly with a cumulative weakening effect on grain structure.(7) Nevertheless they find wide and, with proper care, satisfactory industrial application.

The Organolites

The organolites derive from two methods of preparation:

(1) In 1935 the discovery was made at the Chemical Laboratories at Teddington(8) that polymeric resins produced by the action of formaldehyde on wide range of natural tannins—preferably sulphonated and notably those derived from quebracho wood—possess powers of exchanging sodium ion for other cations when regenerated with salt. They also will, when regenerated with dilute acid, exchange hydrion against all other cations.



CHARACTERISTICS OF REGENERATION OF BASE EXCHANGE MATERIALS.

(2) Independently a second discovery was made that base exchange properties could be[9] developed in ordinary bituminous coal by sulphonation, either with fuming sulphuric acid or chlorosulphonic acid at 90°C. or with sulphur trioxide at 180°C. or with sulphur trioxide dissolved in liquid sulphur dioxide at 15°C. among possible methods. These products also exhibit cation exchange when regenerated with acid.

Each of these methods of preparation undoubtedly results in the production of bodies with labile phenolic groupings with the desired exchange properties. Tannins are essentially polyphenols and the existence of phenolic and carboxylic acid groupings in coal is well known. Moreover the effect of sulphonation is to develop the acidity of the phenolic grouping.

It is known that the sulphonated coals are finding wide commercial application. They are said to be physically robust, naturally resistant to acids and unaffected by water of higher pH's within reasonable limits; their use at a pH of 10.5 has been authenticated, although it is to be expected, from their acid nature, that there must be an upper limit to their resistance to alkali. They are regnerated by 4–5% salt solution in the normal way when used in base exchange as with other base exchange materials. When used on the acid cycle for hydrion exchange they are regenerated with 4% HCl or H_2SO_4. The efficiency of regneration is similar to that of regeneration with salt; but it may be assumed that to economize acid the bed is regenerated to lower capacities to obtain a high acid efficiency.

Acid Removing Resins

The discovery of cation exchange was accompanied by complimentary discovery of anion exchange[8], by resins of an alkaline nature formed by the polymerization of organic amino bodies, such as p-phenylene diamine in which $-NH_2.OH$ groupings exist which can change into NH_2Cl, $-NH_2.SO_4$, &c., groupings when contacted with the appropriate acid: $NH_2OH + HCl = -NH_2.Cl + H_2O$.

The amine salts so formed, attached of course to the body of the resin, can be regenerated by treatment with 2% caustic soda or sodium carbonates:

$$NH_2Cl + NaOH = NH_2.OH + NcCl$$

$$2(-NH_2Cl) + Na_2CO_3 + H_2O = 2(-NH_2OH) + 2NaCl + CO_2.$$

Capacities of these acid removing resins are high; figures of the order of 10–20,000 grains per cu.ft. have been quoted for them[6] and there is reason to believe that some of the more recent methods of preparation described go beyond the original resins in efficacy[10, 11].

Removal of Saline Constituents from Water—Demineralization

The great interest of the application of these resins is that of removal of all saline constituents from water. The term "demineralization" has been applied to this application. By such means the production of water of "distilled quality" may be effected at comparatively low cost for boiler feed to high pressure boilers and for purposes where large volumes of water are required for washing purposes in chemical manufacture as in the photographic trade and the preparation of oxide catalysts.

The water first passes through the cation exchange media where all salts are turned into the corresponding acids forming a dilute solution of mineral acids and carbonic acid from the bicarbonate present.

$$\text{Ca or Mg or 2Na} \begin{cases} (HCO_3)_2 \\ Cl_2 \\ SO_4 \end{cases} + 2HZe = \text{Ca or Mg or 2Na} - Ze_2 + \begin{cases} H_2O + CO_2 \\ 2HCl. \\ H_2SO_4 \end{cases}$$

This solution of weak acids then flows through the subsequent bed of acid removing resin where neutralization is effected with retention of their anions as explained above except for the bicarbonate ion which passed through unchanged. The resultant effluent is free from all but the last traces of mineral salts and is of very low conductivity. It may be noted that the very small quantity of silica which is always present in many waters is not removed—silica is too weak an acid to be affected. Equally small traces of ammonia are left in presumably because this is too weak a cation (Table VI).

TABLE VI.—Demineralization of M.W.B. Water (Analysis in Parts per 100,000).

Before Treatment.	
Calcium carbonate $CaCO_3$	20.0
Calcium chloride $CaCl_2$	3.9
Magnesium sulphate $MgSO_4$	1.8
Sodium sulphate Na_2SO_4	3.1
Silica SiO_2	0.7
Total dissolved solids	29.5
After Demineralization.	
Calcium carbonate $CaCO_3$	*Nil*
Sodium sulphate Na_2CO_3	0.5
Sodium chloride NaCl	0.2
Sodium sulphate Na_2SO_4	0.05
Silica SiO_2	0.07
Total dissolved solids	1.45

The cost of treatment varies with the saline content of the raw water. A water as the above in Table VI would cost perhaps 6d.–1s. per 1,000 gallons. A water of 60 or 90 grain T.D.S. would cost 3s.–5s. per 1,000 gallons. Although these costs are great by water treatment standards they are many times less than the cost of distilling water.

One item which must not be overlooked is the amount of water required to wash out the exchange vessels after regeneration to ensure that they are free from the salts and acid contained in the spent regenerative solutions. As much as 25% of the water entering the plant must be rejected, first in washing out the first exchange vessel; and then when metallic cations cease to appear in this effluent, it must be switched on to the second vessel to wash out regenerative solution there. It is therefore evident that any development which could raise the capacity of these materials and make an appreciable reduction in volume of the exchange bed and vessel will correspondingly reduce the volume of wash water would correspondingly increase the overall efficiency of treatment.

The treated water from this process is, of course, charged with carbon dioxide from hydrion exchange with bicarbonate and for that reason must either be outgassed with air or, where necessary, de-aerated.

Treatment of Alkaline Waters[5]

The complete demineralization of water is an achievement of limited interest to gas engineers. But the adaption of hydrion exchange to the treatment of waters high in alkalinity and in temporary hardness is of much wider appeal.

Waters containing sodium bicarbonate are notably difficult to treat. Prior to the discovery of the hydrion exchange properties of the organolites the only, in any degree successful, method of treatment involved neutralization with sulphuric acid followed by base exchange, a process which did nothing to reduce the total dissolved solids, which are not infrequently high in these waters.

A typical analysis of an untreated alkaline well water is given in Table VII. The characteristically high content of sodium bicarbonate is said to be caused by water which has picked up a high calcium bicarbonate hardness then filtering upwards through a greensand strata, where it undergoes base exchange. These conditions occur in the London Basin and wherever the standing level of the water is in the greensand strata London well waters are markedly alkaline. The content of sodium bicarbonate may be as high as 25–35 parts calcium and magnesium bicarbonates from 5–10 parts and sodium chloride up to 50 parts per 100,000.

It is inadvisable to use these waters untreated they are prone to priming and are very corrosive if high in sodium chloride.

It has been found, however, that if such waters are passed through a hydrion exchange unit which has only been partly regnerated the exchange of hydrion against other cations is confined to the bicarbonates and they are all turned into carbonic acid which is easily outgassed.

$$NaHCO_3 + HZe = H_2CO_3.$$

The underlying theory of this modification is probably that only the most weekly acid linkages in the exchange body are developed and they are incapable of competing for cations with any acids other than the weak carbonic acid which is almost completely undissociated. It is the formation of this acid which is the directing force in the exchange.

A feature of the regeneration is that, as it is only pursued to a limited degree, it is very efficient; and the acid efficiency of regeneration is in the neighbourhood of 95%, with an equally efficient removal of bicarbonate in exchange.

TABLE VII[5].—"Starvation Treatment" of Alkaline Waters.

	Raw.	Treated.
Calcium carbonate $CaCO_3$	3.0	*Nil.*
Sodium carbonate Na_2CO_3	21.5	3.0
Sodium sulphate Na_2SO_4	2.0	2.0
Sodium chloride NaCl	1.0	1.0
Total dissolved solids	27.5	6.0

The method of treatment has been given the proprietory name of "Starvation Treatment" to describe the starvation of the exchange bed of acid in regneration.

Mixed Salt Plus Acid Regeneration

An extension of this rather remarkable selective treatment of the saline constituents of a raw water is provided by a combination of salt regeneration and "starvation" acid regeneration. By this means a water, apparently by preference of high temporary hardness and low permanent, can be softened with practically complete removal of bicarbonate ion thereby removing the one objection to simple base exchange softening. It may be supposed that the hydrion exchanged links with the bicarbonate ion by preference, and the sodium ion links with what is left—namely, the mineral acids—but whatever the explanation of the treatment its description, coming from several sources, does seem to be one of the technically established facts of the adaption of these ion exchange media. It should be noted that, since the bicarbonate is converted into carbon dioxide, the reduction of solids brought about by removal of bicarbonate is similar to that which is one of the beneficial aspects of line treatment of temporary

hardness; here, of course, the bicarbonate is removed as a gas and not as a precipitate. The method of removal is more expensive than by lime treatment as the cost of acid is about three times that of lime for equivalent amounts. About 10% of the water used must be wasted in washing out after regeneration, as well.

Nevertheless the cost of either "Starvation" of "Mixed" treatment will rarely be more than 1.0d.–1.5d. per 1,000 gallons. The cost of the containing vessels, which are normally rubber-lined steel, may be substantially reduced by using hard wood in place of steel, or, perhaps, as a post-war development, resin bonded plywood. "Starvation" treatment is inevitable for treatment of alkaline waters and mixed regeneration will exert a strong appeal in factories where ground space is limited and the scale of operations do not call for a lime-soda or lime-base exchange plant.[12]

TABLE VIII[6].—Mixed Salt plus Acid Regeneration.

	Raw.	Treated.
Calcium carbonate $CaCO_3$	20.73	*Nil.*
Magnesium carbonate $MgCO_3$	6.38	,,
Sodium carbonate Na_2CO_3	—	3.0
Calcium sulphate $CaSO_4$	0.60	*Nil.*
Magnesium sulphate $MgSO_4$	4.3	,,
Sodium sulphate Na_2SO_4	—	6.75
Sodium chloride NaCl	5.62	5.62
Total dissolved solids	37.63	15.35

De-oiling

De-oiling of condensate is practically inevitable where the condensate is derived from reciprocating steam engines and pumps. The established method of treatment is that of producing a floc by the separate additions of sodium carbonate and alum or sodium aluminate to the water. The floc gathers the oils, which is then filtered out through wood, wool and sand. There is an alternative method relying on the passage of an electric current to serve as the method of gathering the oil. On a small works it may be practicable to introduce the condensate into the softener where de-oiling can go on coincidentally with softening. The capacity of the softener will be thereby reduced and there is no guarantee that de-oiling is so effective as in a special plant of its own.

De-aeration

De-aeration is the final stage in feed water conditioning, and it is becoming increasingly recognized that it is an essential safeguard against corrosion in steam condensing plant—such as benzole plant—and a long term investment against corrosion in boilers. An incidental benefit where vacuum type benzole plant is installed is that the absence of permanent gases in the steam from de-aerated feed water enables a better vacuum to be operated in the still.

The normal type of de-aeration plant operates at 160°–180°F. and is installed in the feed water line to the boiler. Oxygen content should be reduced to less than 0.001% by volume; aerated feed waters usually contain 0.6–0.8%. Hot softening plants, dependent on temperature, effect a marked degree of de-aeration by temperature effect alone; and it may be sufficient to enable the last traces of oxygen to be removed by use of sodium sulphite without recourse to vacuum de-aerators.

On gas-works where, if the water is cold softened, the feed may then be passed on through the first stages of the primary condensers, where it may be raised in temperature to as much as 160°F., equivalent to a heat economy of 1.0 therms/ton in[13] condensers operated in conjunction with a vertical retort installation, it may be advisable to de-aerate this water prior to use in the condensers. This can be effected by cold de-aeration. The plant described for this purpose is a slat packed tower 20 ft. in height with a water loading of up to 30 gallons per sq.ft. per minute. As the amount of gas to be removed is small the power expenditure required by pump or ejector is small. If a steam ejector is used the inlet water to the plant may be circulated through the tubes of the surface condenser of the ejector to economize the heat in the steam used on the ejector. 95% of the air can be removed in this way. The remaining 5% is most economically eliminated by use of sodium sulphite added at the rate of 0.05 lb. per 1,000 gallons. No plant of this type is known as operating in this country, although applications in Australia and America are described in the literature.

Summary

1. Boiler feed water should be of zero hardness, low controlled alkalinity, and free from sludge.

2. Hot lime soda softening or lime-base exchange treatment are suitable treatments; but the latter must be operated so that the water leaving the lime treatment stage is stable.

3. Stability is discussed in relation to modern method of seeding the supersaturation of the softening reactions.

4. Boiler water conditioning is discussed in relation to the benefits derived from phosphate addition which is of material help in conjunction with tannins in control of residual hardness from any softening treatment.

5. The advantages of carbonaceous zeolites and the organolites generally are discussed in base exchange, in complete removal of all saline constituents from water; and in a special sphere of usefulness in the specific elimination of sodium bicarbonate and bicarbonate ion from well waters.

6. De-oiling is discussed.

7. Cold de-aeration is suggested as perhaps more suitable for gas-works conditions than hot de-aeration.

The choice of any one method of treatment is not a matter on which one general opinion can be expressed, but hot lime-soda softening with subsequent filtration and lime-base exchange treatment are the alternatives between which a decision can be taken for the majority of waters.

In conclusion the Author wishes to thank the Directors of the Gas Light and Coke Company for permission to read this Paper and for the facilities provided for the study of the several processes discussed. The advice of many colleagues on the staff of the Gas Light and Coke Company and information provided by a number of water treatment engineering firms has also been greatly appreciated.

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Discussion

Dr. **Akeroyd** (Permutit Company) explained the salient points of modern exchange and his own firms demineralizing plants with the help of some lantern slides, which illustrated installations ranging from bicarbonate and hardness control plant on municipal water supply down to small units producing saline free water for the breaking down of spirits. Emphasis was on compactness and arrangement and operation of valve gear. Valve panels had been developed which permitted rapid and fool-proof operation. The ultimate development was automatic valve gear which was set into operation after a predetermined quantity of water had been treated in the plant by means of an electrical contact made in a water meter on the flow to the plant. Electrically operated valves then performed the successive operations of back washing, regeneration, and return to softening. As a variation the cycle of regeneration operations could be performed automatically, but the gear itself was set in motion by manual operation.

Mr. **Ricketts** (Hertford) said that in his experience, Neckar blow down return plant gave satisfactory treatment. He asked about the efficacy of sodium aluminate and of Calgon (sodium-hexa-meta-phosphate), enquiring if the latter were of use in controlling the precipitation of scale in ammonia washers.

Mr. **Clarke** (Beckton) said that in his opinion the use of direct steam to raise the temperature of a softening reaction could result in the production of too fine a crystalline form of precipitate for rapid settlement. He suggested that this arose from excessive agitation and actual mechanical shock in using the steam. With regard to the "Spiractor" type of plant he had seen examples of this in operation and had been impressed by the small size of plant relative to its throughput, but his information was that there had been considerable carry-over into the filters which shortened the filter runs between backwashings. He thought that it was not a plant which was successful with all types of water. He asked if there were any method of controlling precipitation of silica scale. In the matter of the use of Calgon, he had been using it for some considerable time in gas engine cooling water and had found that any scale formed came down as soft sludge, whereas formerly the scaling of the cylinder jackets had presented a problem of considerable magnitude. He asked too how the cost of demineralizing water compared with lime-soda treatment.

Mr. **Donnelly,** replying, said that blow down return gave good softening results simply because the water carried a very great excess of sodium carbonate; to do this was not good practice. There was the further objection that the blow down carried heat away from the boiler and consumed extra steam in returning what might amount to a considerable quantity of blow down back to the boiler in the boiler feed pumps. These items meant wasted heat and fuel There was nothing that blow down return could do which could not be achieved by hot lime-soda treatment at greater economy in fuel and softening cost. Well substantiated claims were made for the efficiency of sodium aluminate in assisting the precipitation of magnesium hardness and it was an excellent coagulant. The claims made for Calgon in holding up the precipitation of calcium carbonate in the cold were well founded. There was an upper temperature limit to its effect which was about 60°C. He had, himself, used it to prevent the formation of scale in the heat interchange coils of recording calorimeters operating on a circulated water system. Here the maximum temperature reached was 40°C. in the calorimeters themselves. Not only was scale formation prevented, but old scale previously formed in pipes and services was loosened and had to be cleared out of the system. But in ammonia washers the concentration of the precipitant—*i.e.*, ammonia—was so great that it was asking rather a lot of the threshold effect of Calgon. Nevertheless one of the original

uses of Calgon was an inhibitor of precipitation in irrigation systems in which ammonia was added to the irrigant water as a nitrogenous fertilizer. In the matter of silica scale the use of magnesia as a precipitant with the lime had been recommended on the grounds that magnesium silicates would be formed. The supposition was that trouble with silica scale might be expected in water which contained no magnesium hardness. On the cost of demineralization, this depended entirely on the concentration of solids in the raw water, the higher the solids, the more acid and soda ash were required per 1,000 gallons of water and the cost rose proportionately. For M.W.B. water the cost was about 6d. per 1,000 gallons, the water containing about 20 gr. T.D.S. Other waters containing 50–90 gr. T.D.S. might cost about 3s. 6d. per 1,000 gallons. This did not, of course, compare with lime-soda treatment, the cost of which was to be assessed in pence per 1,000 gallons; but the comparison was to be made with production of distilled water, as all saline constituents were removed not merely those responsible for hardness in the water. The cost of production of water by distillation was to be measured, by comparison, in pounds.

Mr. **Deas** (Tottenham), proposing a vote of thanks to the speaker, said that electrolytic potential treatment of water prevented scale formation in the boiler in a very remarkable way. It was, however, a method of internal treatment and did not come within the scope of the Paper. On the subject of blow down return this was not to be confused with continuous blow down which, in his experience, was a great advance on hand operated intermittent blow down. The speaker had given a very complete review of the whole subject of water treatment; the great difficulty was still to select the most suitable plant for a given application.

Mr. **Timmins** (Beckton), seconded, and Mr. **Donnelly** acknowledged the vote.

Heat Treatment of Aluminum and Magnesium Alloys

THE American Gas Association has published a report of a Sub-Committee (Chairman, Mr. C. G Segeler) on Metal Treating and Melting. The Sub-Committee was organized in the Autumn of 1941 for the purpose of studying the position of gas in the heat treatment of aluminum and its alloys. The first year's report, issued in October, 1942, covered an investigation of the existing specifications for aluminum alloys and their heat treatment. One hundred and seven different specifications were checked to see how the requirements for heat treatment might influence the choice of fuel. The Committee was able to demonstrate that no specifications had been issued by any federal agency which would prevent the application of appropriate gas equipment. The report also included general information about aluminum alloys and their heat treatment. One hundred and seven different specifications were checked to see how the requirements for heat treatment might influence the choice of fuel. The Committee was able to demonstrate that no specifications had been issued by any federal agency which would prevent the application of appropriate gas equipment. The report also included general information about aluminum alloys and their heat treatment. There was also a brief outline of the heat treatment of magnesium alloys.

Many of the puzzling difficulties in the heat treatment of these. alloys have been solved during recent months. This has led to a new understanding of how well gas can be applied. This new report furnishes detailed information on the heat treating processes, the types of furnace equipment, and the effect of various furnace atmospheres.

The heat treatment of alluminum alloys of all types can be and is being done successfully with gas. Gas equipment is available from a number of manufacturers that can be depended upon to furnish uniform temperatures without any override, fully capable of meeting the most stringent requirements.

Those aluminum alloys containing magnesium as well as silicon have been found to present greater difficulty than others. The wrought alloys are, in general, heat treated in salt bath furnaces or in indirect furnaces, but experiments have shown that, with suitable precaution, they can be heat treated in direct gas-fired furnaces as well. The cast alloys can be heat treated in direct gas-fired furnaces provided that all the factors entering into their fabrication are considered and controlled.

The second half of the present report deals with magnesium alloys and points out the advantages derived from the use of direct-fired gas furnaces without sulphur dioxide atmospheres. This is a complete change from the recommended procedure of the past, a procedure which led almost exclusively to the adoption of electric furnaces. Announcement of the method of using direct-fired gas furnaces was first made at the Detroit Industrial War Conference in March, 1943. Since that time, considerable additional information on the methods of using direct-fired gas furnaces has been secured.

The following notes are taken from the report in question.

Aluminum

The Gas Industry has a real stake in the present and future development of the aluminum industry because there are so many applications of heat in the manufacture of an aluminum article from the time the ore is mined until the finished product is delivered. A large portion of this gas is needed for the heat treatment of aluminum alloys, for, in contrast to other metals, there is relatively little aluminum which is not heat treated. The report deals primarily with the application of gas to the heat treating process.

This emphasis on heat treated aluminum alloys is, in itself, a relatively modern development, stemming from the widespread use of the so-called strong aluminum alloys needed because of the expansion of the aeroplane industry.

Over a ten-year period, aluminum has jumped into prominence not only by its increased production, but by the steady lowering of its price. To-day aluminum ranks with copper in importance as a metal. Although the tonnage of copper is still greater, the light weight and high strength of aluminum alloys make a pound of aluminum go further.

When peace comes once more, the production facilities for aluminum, which were constructed during the war, offer the possibility of low cost aluminum for all types of metal fabrication. Aluminum and its alloys can be forged, spun, extruded, stamped, cast, and otherwise treated to produce practically any shape product. Aluminum alloys are strong and light, and offer advantages over other metals as a result of these properties. It is most unlikely that the increased capacity for making aluminum will be shut down after the war if any market can be found or developed for the available tonnages. There are already straws in the wind pointing to the great interest in aluminum fabrication on the part of copper and brass mills, many of whom have already installed large amounts of equipment for handling aluminum products.

The fact that aluminum has grown in importance would not justify so much emphasis in a report on gas heat treating, except for the influence that this growth may have upon the use of industrial gas. It is only a few years ago that the bulk of aluminum heat treating was carried out in electric furnaces. In fact, this idea was so widespread that the primary assignment of the 1942 Project No. 1 Sub-Committee of the Metal Treating and Melting Committee of the A.G.A. was to establish whether Federal specifications for aluminum alloys covered the use of gas in a proper manner. Fortunately, this proved to be the case, and the publication of the facts has reassured gas engineers regarding the application of gas to aluminum heat treating. Furthermore, it has focused attention upon this problem.

If it is conceded that aluminum alloys are likely to become the most important non-ferrous metal products, practically all of which require extensive heat treatment, then gas engineers have an important job in learning both the theoretical and practical side of all of the heat treatments which may be involved. The Gas Industry, sells a large amount of gas for this purpose, an amount partially due to the large tonnage and partially to the relatively longer heat treating time required for many aluminum alloy products.

Looking back on the history of applying gas for heat treating in general, it may be remembered how slowly gas reached its present prominent position. There were competitive struggles with other fuels and electricity. There were many arguments about the quality of the product which came from gas operated furnaces. To-day the use of gas is general in both ferrous and non-ferrous heat treating. The last two years have witnessed almost equal progress in the application of gas to aluminum treating.

The aluminum alloys are divided into two general classes, the wrought type and the cast alloys. While both require heat treatment, there has been a greater amount of gas used in the cast alloy field.

It can be assumed, for rough estimating purposes, that 80 therms of gas are required for the heat treatment of one ton of aluminum castings and, consequently, an annual total between 300,000 and 400,000 tons represents a substantial industrial gas load that has many attractive features.

Gas *versus* Electricity

In the heat treatment of aluminum products, there has been keen competition between gas and electricity, the latter having a head-start largely because the wright alloys containing magnesium as well as silicon react to moisture, especially if sulphur compounds are also present. It seemed easier to avoid reactions when no flue products were present, but even in an indirect or an electric furnace, moisture from the air sometimes can cause trouble. If a large stack of cold sheets is put into a furnace, moisture may be condensed and collect between the sheets to cause trouble.

It is only since about 1939 that aluminum castings were heat treated outside af a few of the largest processing plants like the Aluminum Corporation itself. The principal cast products were made with alloys of the copper aluminum family, which is not adversely affected by furnace atmosphere except under unusually bad circumstances. Thus, there always was a certain amount of gas used for heat treating alloys of this type. With the advent of the more specialized alloys containing small amount of magnesium in the presence of silicon, furnace atmospheres became subjects of concern as far as the cast materials were concerned. However, it should also be noted that good work was not the result of using electricity, but depended on its proper application. Unsatisfactory products continue to be produced when improper types of electric furnaces are used.

Electric heat treating equipment was selected by many of the war industries for both wrought and cast products in spite of higher operating

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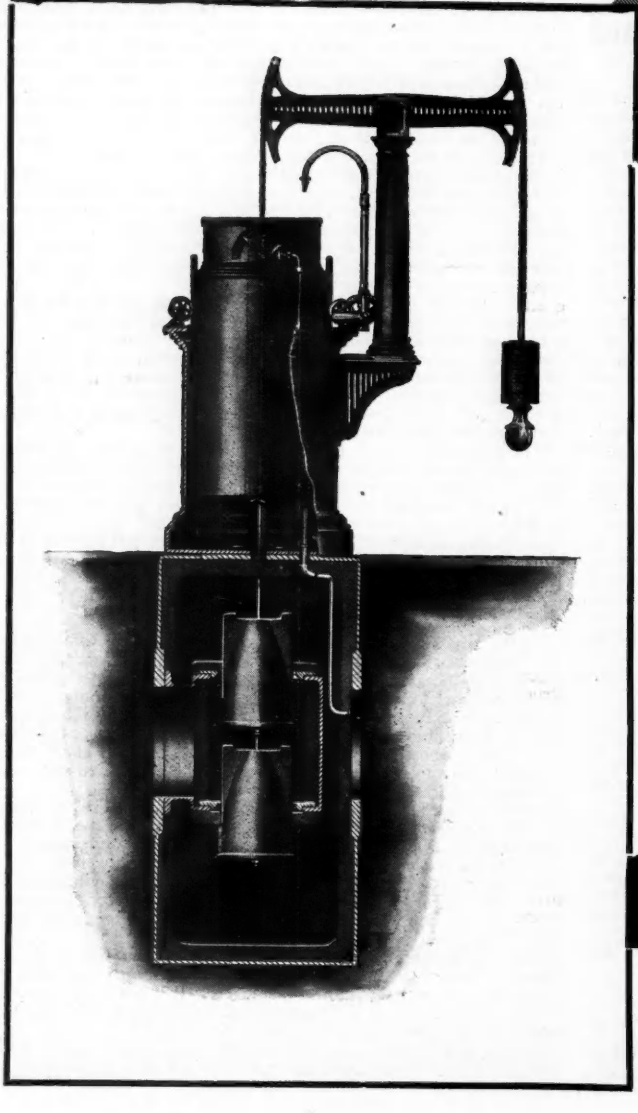

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cost and higher maintenance cost because it was believed that a better product would result. In any event, the material turned out by those electric furnaces which were selected by the first plants to be constructed turned out to be satisfactory, and there was thus a natural tendency for subsequently erected plants to follow the line of least resistance and use the same source of heat. Electricity received considerable publicity, and it was favoured by certain Government specifications.

The Gas Industry persistently attacked the problem and, in a number of locations, gas was selected for heat treating various aluminum products. These proved to be just as good as anything that could be produced in electric furnaces and at much less cost. The trend to gas quickly turned upward. The Gas Industry can now prove its fuel is second to none for heat treating aluminum provided that the proper type of equipment is used for the purpose. Certain large aluminum production centres now use far more gas than electricity, completely reversing the earlier trend.

Use of Gas in the Aluminum Industry

Heat is required in large amounts in the driers employed after chemical purification of aluminum ores. There are a number of natural gas applications in this field. The purified ore is shipped to the electrolytic reduction plants. This process uses electricity both for the heating of the cryolite baths and for electrolyzing the alumina. There is an opportunity for gas application for the remelt furnaces, ladle heating, and auxiliary plant uses.

The unrefined pig made in this manner contains dross and other non-metallic impurities which are removed by subsequent remelting, at which time appropriate alloys are added. These remelt furnaces are of various types, depending upon the product involved, the larger ones being open hearth construction, largely fired by coke in the United States. However, there are some gas-operated open hearth aluminum furnaces from which the metal is cast into shapes convenient for subsequent manufacture as wrought alloy. Sometimes the remelting is followed by casting directly into finished or semi-finished shape. Gas-fired furnaces of the pit crucible or tilting crucible types have had considerable application in this field. It seems advisable, however, to suggest that further studies be undertaken of this application in order to improve the finished castings, particularly in the matter of freedom from pinholes or other gassy defects. Numerous commercial flux covers are available for the protection of molten metal from furnace melting atmospheres. Use of these simplifies degassing and helps to produce a uniform cast structure. The degassing of aluminum castings is a most important step, and some of the large manufacturers have given a great deal of attention to the methods which can be most effectively employed. Among these is the washing of the metal during holding by bubbling chlorine gas through the molten metal just prior to casting. Another procedure is to treat the metal with suitable chemical degassing agents, such as cryolite, sodium chloride and fluoride, and volatile metallic chlorides.

A number of reports on melting practice indicate that a high hydrogen content of the fuel is undesirable. While it is true that gassy castings can sometimes be traced to such a cause, other factors appear to be more important. Among these the following should be considered : Too high a metal temperature, improper degassing, improper gating, poor pouring technique, faulty pattern layout, and undue holding of the metal.

The aluminum intended for wrought alloys is extruded or rolled into the desired shape. There is therefore considerable deformation which would cause cracking of the relatively brittle cast ingots. As a consequence, the first forming is carried out at elevated temperatures, so that there is a preheating operation generally carried on between 850° and 900° which also serves to homogenize and soften the cast structure so as to prevent cracking.

Materials that are cold formed become hardened as a result of deformation, so that intermediate annealing operations are required from time to time to soften the metal. These are carried out by heating to the annealing range which is between 640° to 670°F.

Gas is also used as a principal melting fuel in the aluminum die casting field.

From the point of view of the Gas Industry, the most significant heat treating operation is the solution heat treatment and ageing for maximum strength and for other optimum physical properties. Solution heat treatment is commonly called just "heat treatment of aluminum." It is followed by the appropriate quench and may subsequently require a further precipitation or age-hardening treatment. The opportunity for using gas for this work will undoubtedly expand with increasing production of aluminum alloys both during the war and in the future.

Heat Treating Requirements

The solution heat treatments vary in time and temperature, depending upon the alloy in question and also whether gas salt baths or gas recirculating convection furnaces are being used. Wrought alloys take only a fraction of the time required for cast alloys.

Temperature controls must be accurate—in several senses. First they must be calibrated correctly; second, they must represent the actual internal temperature of the parts being heat treated; third, temperatures throughout a load must be absolutely uniform ± 5°F. The reasons will be clear if it is remembered that the object in most cases is to get the temperature as high as possible without causing any melting of eutectic constituents* in the alloy. Material once damaged by overheating cannot be restored by heat treatment. Since the eutectic particles vary somewhat from batch to batch even of a single alloy.

The gas engineer is prone to assume that the heat control maker and the furnace designer have taken care of these requirements of temperature control. The equipment is built to achieve the necessary control, but the introduction of the actual work load often changes furnace characteristics. If the basic requirements are kept in mind, it should be possible to trace down the cause of trouble when encountered.

The choice of furnace or heating method for heat treating aluminum allows a considerable latitude, although, in any case, uniformity and accuracy of temperature control are paramount, as has already been outlined. The widespread use of salt bath furnaces in England and on the west coast in the United States, and in occasional plants elsewhere, has been influenced by the spread of heating which is made possible by salt bath and the fact that perfect temperature uniformity was not so readily available with air furnaces at the time that the first aluminum heat treating installations were made.

The salt bath furnaces save about 30% of the time required by an air furnace and if the settings are properly designed a high degree of temperature uniformity can be maintained. Burner types and location must be selected so as to give a wide degree of control for turn down, and it may be necessary to install several thermostats for zone control of burners. Since temperatures in salt baths are not allowed to go below 500°, they have a high load factor seven days a week.

The metallurgical requirements as well as pot life make it desirable to use controls which will prevent overheating in a positive manner even in event of electric current failure or excess gas input or because of residual heat in the firebox.

Settings for the salt baths have been designed for underfiring with atmospheric burners or low pressure proportional inspirators, side firing with radiant cup burners, and immersion firing. There are some companies, especially in England, that feel that melting of the salts should start at the top to prevent build-up of pressure within the frozen salts.

Disadvantages of the salt bath are due to the more difficult handling, the higher costs due to increased fuel consumption, pot failures, and greater investment. There may also be difficulty in complete removal of the salts in the case of complex shapes. Because of these and related points many of the recent installations for heat treating wrought aluminum alloys and almost all of the newer furnaces for cast alloys have been of the recirculating air type. The exceptions to this trend on the west coast have already been indicated.

As recently as two years ago, electrically-heated furnaces were frequently selected in the belief that they would provide greater uniformity of temperature control. It has, however, been shown, in several instances, that the localized radiation from resistors in electric furnaces actually causes a non-uniform temperature and has caused "burning" of pieces nearest to the heating elements. In addition, it is generally true that electric furnaces are higher in first cost and are markedly higher in operating and maintenance cost than gas furnaces. Therefore, gas equipment received a great impetus as soon as it was demonstrated that equally good results could be obtained. In fact, one large manufacturer of furnaces in Detroit states that they have shifted their business from 80% electric and 20% to 85% gas furnaces and 15% electric furnaces at the present time.

Gas furnaces of the recirculating convection type provide uniform temperatures, controllable to within ±5°F. There is no exposure of aluminum to flue gases in the indirect type of recirculating furnace, which should be used for heat treating most of the wrought alloys and the more sensitive castings.

However, there are advantages in first cost and operating cost in using a direct-fired gas furnace in which a small percentage of flue gases will be in contact with the work. In general, cast alloys of dense structure can be successfully heat treated in direct-fired gas furnaces. It has been suggested that all castings regardless of the alloys, which are free from gas porosity, will resist the entrance of flue products and thus prevent intergranular oxidation for other destructive effects. Thus the foundry practice has a very important bearing upon the desirability of using direct-fired furnaces.

Gassy castings from whatever cause are an indication of poor foundry practice. The gases may be introduced from the melting furnace atmosphere if the metal is melted without protection and in an unfavourable atmosphere (should be slightly oxidizing). Gases may also be introduced if molten metal is held for excessive lengths of time prior to pouring after degassing. It is nearly impossible to obtain sound castings without careful degassing of the metal just prior to pouring. The greater the lapse of time at this point, the less sound will be the resulting castings, and subsequently, there will be less adequate response to heat treatment regardless of the type of heat treating equipment which is being used. Microscopic gas channels which form during the freezing of gas to metal make castings quite susceptible to corrosion, blistering, and blackening during heat

* Their melting point is lower than that of the alloy as a whole.

treatment. The direct-fired oven may tend to accentuate this difficulty, but compounds can be used to overcome difficulty from moisture.

Magnesium

The increase of magnesium production on a percentage basis has been extremely high as is to be expected with an industry that was practically in its infancy in the United States in 1939. The tonnage of magnesium produced during 1943 puts this metal in the position where aluminum was in the pre-war years. The price of magnesium at 21 c. per pound is about at the pre-war aluminum levels. These points naturally invite a comparison between aluminum and magnesium and speculation as to its probable future.

Based on present figures, the amount of gas required for the handling of magnesium products is considerably smaller than that required for aluminum. There might, therefore, be less immediate interest in this market for gas. However, those particular manufacturers who are using magnesium are looking to the Gas Industry for assistance in the solution of their heat treating problem. Locally, therefore, magnesium work may assume considerable importance, sufficient, at least, to justify the Committee in bringing up-to-date the available information.

Magnesium, like aluminum, is a widely distributed element in the earth's crust, but the principal sources from which it is commercially produced are the magnesium-containing brines, as in Michigan, the ocean water, as in Texas, and two minerals, magnesite, $MgCO_3$, and dolomite, the double carbonate of calcium and magnesium. Various processes are used to convert these materials into metallic magnesium. The brines are electrolytically treated, and the solid ores after conversion to magnesium oxide are reduced either by the ferro-silicon process which uses gas for heating the retorts or the carbo-thermic process which uses natural gas for the shock-cooling of magnesium vapour.

The relatively pure magnesium so produced is not used to any extent in the metal trades, but is alloyed primarily with aluminum, zinc, and manganese. The purpose of using alloys is to improve the low strength of pure magnesium. The mechanical properties of the alloys are, in general, about in the same range as aluminum alloys. Magnesium alloys, however, are markedly lighter, in general weighing about 0.066 lb. per cu.in contrasted with a weight of about 0.1 lb. per cu.in. for aluminum alloys. This difference of 35% in the weight of magnesium alloys makes them highly desirable for use, particularly in military aircraft. Whether they will be as widely adopted for civil use is open to doubt on account of certain advantages of aluminum alloys which may overbalance the weight differential.

Magnesium alloys can be used for sand castings, permanent mould castings, and die castings. Wrought magnesium products are available in various shapes and as tubing, sheet or forgings.

So far the Sub-Committee confined its studies to the heat treatment of magnesium sand castings, since this appeared to be the most important field for the application of industrial gas. Although there are a number of sand casting alloys in use, compositions similar to the Dow Chemical Company's "Dow Metal H" are most frequently employed. This alloy has between 5.3% and 6.7% aluminum; 2.5% to 3.5% zinc; at least 0.15% manganese, and not more than 0.5% silicon. Magnesium makes up the remainder except for minor impurities. This type of alloy appears to be the best for general foundry use and is quite suitable for applications where salt water corrosion resistance may be a factor. Another type of alloy that is used to some extent is similar to the Dow Metal "C" alloy in which the aluminum is between 8.3 and 9.7% and the zinc 1.7% and 2.3%, manganese at least 0.1%, silicon not over 0.5%, and the balance magnesium except for minor impurities. This type of alloy is recommended for maximum pressure tightness and for permanent mould castings.

Use of Gas in the Magnesium Industry

There is a striking difference between aluminum and magnesium because, thus far, there is no process for making aluminum by the use of gas, whereas the direct reduction of magnesium ores is being successfully carried out by two processes in which large amounts of gas are being employed. The carbo-thermic processes uses carbon to reduce MgO to magnesium vapour which is shock cooled with gas.

The second process, originally developed in Canada, has been adopted by a number of United States plants. Gas is used in this process to heat retorts in which the magnesium is sublimed from the calcined ore by the reducing action of ferro-silicon.

Regardless of how the magnesium may have been manufactured, it is usually melted in gas or oil fired furnaces. In general, melting furnaces with steel pots are used, but experiments with reverberatory furnaces are under way and give promise of considerable success. The principal objection to the steel crucible is its relatively short life, making not only a costly, frequent replacement, but introducing the hazard of fire if molten magnesuim is spilled upon the burners or on the floor. The foundry practice for magnesium is highly specialized and quite different in certain respects than that required for other metals.

Although magnesium castings may be used as cast, it is frequently desirable to heat treat them in develop maximum physical properties. This heat treatment is carried out in two parts: First, solution heat treatment to increase the tensile strength and the elongation. This is generally applied for those products which require shock resistance. When increased hardness and a high yield strength are required, a subsequent ageing or precipitation treatment is also used. This type of heat treatment is quite frequently necessary for aircraft engine parts.

Heat Treatment of Magnesium Alloy Castings

The purpose of heat treating magnesium alloys is quite analogous to the treatment of aluminum alloys inasmuch as the first step is to get as much as possible of the alloying elements into solid solution with the magnesium. The treatment requires holding the cast alloy at a temperature high enough to dissolve these constituents in the magnesium matrix, but not to melt them, and then to cool the work rapidly so as to maintain the supersaturated condition down to room temperatures. This increases the tensile strength, the ductility, and the toughness of the alloy. It is carried out at a temperature 500°F. to 800°F., depending upon the exact alloy composition, but the most generally used alloys are heat treated at 730°F. for alloys like Dow Metal "H" and 760°F. for alloys like Dow Metal "C." After castings are cool, they may be given a precipitation or ageing treatment similar to that given aluminum alloys. This produces maximum hardness and yield strength although at some sacrifice of elongation.

TABLE Ia.—Typical Solution Heat Treatment for Magnesium Alloys.

Alloy.	Temperature.	Time.	Cooling.
Dow Metal "H"	730°F.	12 hrs.	In air outside furnace.
" "C"	760°F.	20 "	" " "
Alloys without zinc	780°F.	20 "	" " "

TABLE Ib.—Typical Precipitation Treatment for Magnesium Alloys.

	Temperature.	Time.	Cooling.
All alloys	350°F.	12 to 20 hrs.	In air outside furnace.

Note 1: Temperatures should not be increased although time may be lengthened to develop properties in heavy load furnaces.

Note 2: Black powder spots after solution heat treatment indicate "burning," and castings should be rejected. Furnace conditions should be carefully checked to determine cause of overheating.

The different temperatures required for solution heat treatment of the castings are primarily due to the presence of eutectic particles having a relatively low melting point. The amount of zinc in the alloy seems to influence this more than anything else. As the zinc content is increased, the temperature at which it can be heat treated is lowered. There is generally a definite segregation of increased amounts of zinc in that part of a casting which was the last to freeze.

On account of the phenomenon described in the preceding paragraph and, in general, because of the ease of damaging magnesium castings, there should be ample time to allow the eutectic and alloy particles to diffuse and to dissolve into the magnesium without melting or burning out. This diffusing and dissolving action unfortunately does not take place at low temperatures. It is only above 500°F. that solution is sufficiently rapid to be effective. This condition gives rise to the two step heat treatment recommendations found in the literature.* One of the most successful pioneer users of direct-fired gas furnaces follows a modified procedure, which is described as follows, and which is believed to produce superior results.

* One very large Mg foundry using a continuous solution heat treating furnace direct gas-fired states that the slow heating up has not been found necessary in his equipment.

(*To be continued*)

Diary

Sept. 8.—North British Association of Gas Managers: Annual Meeting, Edinburgh.

Results of the Past Year's Operation of the Lincoln Gas Department were "better than for any other period in the history of the undertaking" according to a report presented at the last meeting of the City Council. Ordinary consumers, other than those governed by a coal clause, will receive a rebate of 15% on their gas accounts for this year, at a cost to the Department of £15,000. Mr. G. Wright, Engineer and Manager, reported that the 25% cut in consumption called for by the Ministry of Fuel and Power had been very well observed by industrial consumers. The Gas Committee has intimated its willingness to join a conference of local authorities owning gas undertakings to consider post-war planning.

GAS PRODUCTS PRICES

The London Market July 31.

A Government Order came into effect on March 1 controlling the price of Benzole and Coal Spirit and replacing the Control of Coal Tar Naphtha and Xylole Order, 1943.

The Order is known as the Control of Benzole and Coal Spirit Order, 1944 (S.R. & O. 1944, No. 172).

By this Order the price of Motor Benzole is fixed at 2s. per gallon. The Order also lays down the method of evaluating Crude Benzole.

The Order also calls for periodical returns to the Ministry of Fuel and Power from all producers of Crude and Refined Benzole.

The only item of interest in connexion with the Coal Tar products market is the issue of Government Order designated the Control of Toluene (No. 4) Order, 1944 (S. R. & O. 1944, No. 170), which contains an amendment of the Control of Toluene (No. 3) Order, 1943.

Prices of Coal Tar products are unchanged.

The Provinces July 31.

The average prices of gas-works products during the week were: Pitch and Crude Tar,* Toluole, naked, North, 90's, 1s. 11d. to 2s. 1d., pure, 2s. 7½d. (controlled by the Control of Toluene No. 3 Order, dated July 14, 1943, operative from July 20, 1943). Benzole and Coal Spirit, also Coal Tar Naphtha and Xylole, are now controlled by the Control of Benzole and Coal Spirit Order, 1944, dated Feb. 18, 1944, S. R. & O. 1944, No. 172, operative from March 1. Carbolic acid, 60's, naphthalene, anthracene, creosote oil (hydrogenation), coal tar oils (timber preservation, &c.), and strained anthracene oil controlled by the Coal Tar Products Prices Order, 1943, dated Oct. 20, 1943 (S. R. & O. 1943, No. 1528), operative from Nov. 15, 1943.

* In regard to pitch and crude tar prices we would ask readers to refer to the editorial note on p. 396 of the "JOURNAL" for Sept. 10, 1941.

Scotland July 29.

Quiet conditions have prevailed during the week. Refined tar*: Yield to distillers is 4½d. per gallon *ex* Works, naked. Creosote oil: Timber preserving quality,* 5½d. to 6½d.; hydrogenation oil,* 5½d.; low gravity or virgin oil,† 7½d. to 7½d.; benzole absorbing oil,* 6½d. to 8d. per gallon. Refined cresylic acid* is 3s. 6d. to 4s. 6d. per gallon *ex* Works, naked, according to quality. Crude naphtha†: 6½d. to 7d. per gallon. Solvent naphtha*: Basic prices delivered in bulk, 90/160 grade, 2s. 8d., and 90/190 Heavy naphtha, Unrectified, 1s. 10½d.; Rectified, 2s. 2d. per gallon. Pyridine†: 90/160 grade, 13s., and 90/140 grade, 15s. per gallon.

* Price controlled. † Uncontrolled.

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GAS STOCKS AND SHARES

During the greater part of last week the activity among industrial shares continued with rising prices, but towards the close some reaction set in due to a falling off in support. This was more or less expected in view of the sharp gains made in some quarters. British funds were firm throughout.

The volume of business in the Gas Market showed little fluctuation and there were very few price changes, the only one of note being the rise of 40s. in Cape Town 4½% preference to 6½. The feature of the week was the announcement by the Directors of the Gas Light & Coke Company of a dividend of 2½% on the Ordinary stock for the June half-year. For the same period last year the rate was 1½%, and 2½% was paid for the December half-year. The announcement came after hours on Thursday, and at the opening on Friday the price improved 1s. 6d. to 23s. 6d. and closed only slightly lower.

During the month of July there were comparatively few quotations altered, although apart from some *ex div.* markings all changes were in an upward direction. A number of debenture issues hardened a few points.

The following changes in prices were recorded during the week:

OFFICIAL LIST

British Ord.	120—125	+2
Cape Town 4½ p.c. Pref.	6—7	+40/-
Gas Light Units	21/3—22/3	+/-
South-Eastern Gas Corporation Ord.	20/—21/-	+/-
South Metropolitan Ord.	88—91	+1

Quotations on the London and Provincial Stock Exchanges

OFFICIAL LIST

Issue. £	When ex-Dividend.	Dividends Interest. Amnt. or Rate% Prev. Hf. Yr. Actual.	Last Hf. Yr. Actual.	NAME	Quotations July 27
1,767,439	March 13	20/-	20/-	Alliance & Dublin Ord. ...	100—110
374,000	June 26	2	2	Do. 4 p.c. Deb.	97—102
891,664	May 8	6d.	6d.	Assed. Gas & Water U'd'ts Ord.	22/3—23/3
388,938	,,	7½d.	7½d.	Do. Deferred	23/—24/-
500,000	,,	2½	2½	Do. 4½ p.c. Red. Cum. Pref.	19/9—20/9
535,545	,,	2	2	Do. 4 p.c. Red. Cum Pref.	20/—21/-
341,966	,,	2	2	Do. 4 p.c. Irred. Cum. Pref.	17/9—18/9
561,370	Feb. 14	70/-	70/-	Barnet Ord. 7 p.c.	155—160
300,000	June 12	8¾d.	10¾d.	Bombay, Ltd.	34/6—36/6
690,407	Feb. 14	70/-	70/-	Bournemouth 7 p.c. max. ...	155—160
362,025	June 12	2	2	Do. 4 p.c. Deb. ...	100—105
659,955	Feb. 28	25/-	45/-	Brighton, &c., 5 p.c. Con. ...	100—105
855,000	March 13	60/-	60/-	Brit. Gas Light Ord.	120—125
545,000	June 26	2½	2½	Do. 5½ p.c. 'B' Cum. Pref.	108—113
120,000	,, 12	2	2	Do. 4 p.c. Red. Deb.	94—99
10,000	Nov. 6 '33	4/6	4/6	Cape Town, Ltd., 4½ p.c. Cu. Pf.	6—7
626,860	July 17	50/-	70/-	Cardiff Con. Ord.	120—125
24,500	May 30	8¾d.	8¾d.	Colombo 7 p.c. Pref.	21/6—23/6
764,169	March 27	4.78d.	4.78d.	Colonial Gas Assn. Ltd. Ord. ..	12/6—17/6
400,000	,,	7.649d.	7.649d.	Do 8 p.c. Pref. ...	15/—20/-
1,748,090	July 22 '40	30/-	30/-	Commercial Ord.	63—68
620,000	June 15	1½	1½	Do. 3 p.c. Deb.	70—75
286,344	Feb. 21	2½	2½	Do. 5 p.c. Deb.	110—115
807,560	,,	60/-	60/-	Croydon sliding scale	123—128
644,590	,,	50/-	50/-	Do. max. div.	105—108
620,385	June 26	2½	2½	Do. 5 p.c. Perp. Deb. ...	120—125
179,500	Feb. 14	50/-	50/-	East Surrey 'B,' 5 p.c.	103—108
176,461	June 26	2½	2½	Do. 5 p.c. Deb. (Irred.)...	120—125
239,135	Nov. 8	6d.	6d.	Gas Consolidation Ord. 'A' ...	20/—21/-
250,000	,,	4½	4½	Do. Ord. 'B' ...	19/—21/-
250,000	May 8	2	2	Do. 4 p.c. Red. Cum. Pref.	18/—20/-
19,107,811	Feb. 14	3¾d.	6d.	Gas Light & Coke Ord. ...	21/3—22/3a
2,600,000	,,	35/-	35/-	Do. 3½ p.c. max.	78—81
4,477,106	,,	2	2	Do. 4 p.c. Con. Pref. ...	98½—101½
2,993,000	July 10	1¾	1¾	Do. 3½ p.c. Red. Pref. ...	98—101
8,602,497	May 30	1½	1½	Do. 3 p.c. Con. Deb. ...	84—87
3,642,770	,,	2½	2½	Do. 5 p.c. Red. Deb. ...	107½—110½
3,500,000	,,	2½	2½	Do. 4½ p.c. Red. Deb. ...	107—110
700,000	March 6	1½	1½	Do. 3½ Red. Deb. ...	97—100
5,600,000	May 13 '40	80/-	80/-	Imperial Continental Cap. ...	95—100
43,820	Jan. 31	1½	1½	Do. 3½ p.c. Red. Deb. ...	97—100
231,978	Feb. 21	50/-	50/-	M.S. Utility 'C' Cons.	100—105
918,657	,,	2	2	4 p.c. Cons. Pref.	95—100
675,000	May 1	‡40/-	‡40/-	Montevideo, Ltd.	82—87
300,000	April 24	70/-	80/0	Oriental, Ltd.	140—145
368,537	June 12	40/-	57/6	Plymouth & Stonehouse 5 p.c.	106—111
621,667	Feb. 7	72/6	72/6	Portsmouth & Gosport Cons.	121—126
2,381,363	May 15	†9¾d.	†9¾d.	Primitiva Holdings, Ltd. Ord.	9/—11/-
233,900	June 12	3	3	Do. 6½ p.c. Red. Cum. Pref.	97—102
648,999	,, 26	6¾	6¾	Severn Val. Gas Cor. Ltd. Ord.	21/9—22/9
597,972	March 13	2½	2½	Do. 4½ p.c. Cum. Pref. ...	20/6—21/6
2,528,714	May 22	3½d.	6d.	South East'n Gas Cn. Ltd. Ord.	20/—21/-
1,000,000	Feb. 21	2½	2½	Do. 4½ p.c. Red. Cum. Pref.	20/3—21/3
1,068,869	,,	2	2	Do 4 p.c. Irred. Cum. Pref.	19/3—20/3
6,709,895	,, 14	†20/-	†60/-	South Met. Ord.	88—91
1,135,812	,,	3	3	Do. 6 p.c. Irred. Pref. ...	123—128
850,000	,,	2	2	Do. 4 p.c. Irred. Pref. ...	93—98
1,895,445	June 26	1½	1½	Do. 3 p.c. Perp. Deb. ...	83—87
1,000,000	July 17	2½	2½	Do. 5 p.c. Red. Deb. ...	102—107
1,543,795	Feb. 7	40/-	60/-	South Suburban Ord. 5 p.c ...	112—117
512,825	,,	2½	2½	Do. 5 p.c. Perp. Pref. ...	107—112
500,000	,,	2	2	Do. 4 p.c. Perp. Pref. ...	96—101
250,000	,,	1¾	1¾	Do. 3½ p.c. Red. Pref. ...	90—95
888,587	June 12	2½	2½	Do. 5 p.c. Perp. Deb. ...	120—125
750,541	Feb. 7	50/-	60/-	Southampton Ord.	105—110
350,000	,, 14	2½	2½	Swansea 5½ p.c. Red. Pref. ...	100—105
1,076,495	,, 21	50/-	50/-	Tottenham & District Ord. ...	113—118
338,555	,,	2½	2½	Do. 5 p.c. Pref.	107—112
453,380	June 12	2	2	Do. 4 p.c. Perp. Deb. ...	98—103
1,247,505	May 30	4¼d.	7¼d.	U. Kingdom Gas Cor. Ord. ...	21/—22/-
1,085,952	,, 15	5¾d.	5¾d.	Do. 4½ p.c. 1st Cum. Pref. ...	21/—23/-
772,709	,, 15	4¼d.	4¼d.	Do. 4 p.c. 1st Red. Cum.Pref.	19/—21/-
745,263	June 19	5¼d.	5¼d.	Do. 4½ p.c. 2nd Non.Cum. Pf.	17/—19/-
1,200,000	March 13	1¾	1¾	Do. 3½ p.c. Red. Deb. ...	97—102
380,608	May 22	66/3	66/3	Uxbridge, &c., 5 p.c.	119—124
1,371,138	July 17	50/-	50/-	Wandsworth Consolidated ...	112—117
2,525,768	,,	2	2	Do. 4 p.c. Pref.	98—101
1,343,964	June 12	2½	2½	Do. 5 p.c. Deb.	120—125
383,745	,,	2	2	Do. 4 p.c. Deb.	97—102
558,342	Feb. 14	50/-	50/-	Watford & St. Albans Ord. ...	112—117
300,000	June 5	1¾	1¾	Do. 3½ p.c. Red. Deb. ...	95—100

SUPPLEMENTARY LIST

Issue. £	When ex-Dividend.	Dividends Interest. Amnt. or Rate% Prev. Hf. Yr. Actual.	Last Hf. Yr. Actual.	NAME.	Quotations July 27
351,685	June 12	2½	2½	Brighton, &c., 5 p.c. Perp. Deb.	117—122
415,250	,,	2	2	Bristol Gas Co., 4 p.c. New Deb.	100—103
140,205	Feb. 21	70/-	70/-	Cambridge, &c., 7 p.c. Cons. 'B'	140—145
295,932	March 13	50/-	50/-	Cheltenham, 5 p.c. Cons.Ord....	98—103
42,500	June 12	2	2	Do. 4 p.c. Perp. Deb....	100—105
150,000	Feb. 21	2	2	Croydon Gas, 4 p.c. Pref. (Irr.)	93—98
130,000	June 26	2	2	Do. 4 p.c. Deb. ...	97—102
146,700	Feb. 14	2½	2½	East Surrey, 5½ p.c. Pref. 'A' ...	110—115
53,220	,,	3	3	Do. 6 p.c. Cum. Pref. ...	120—125
...	Aug. 19 '40	40/-	40/-	Eastbourne, 'B' 3½ p.c.... ..	97—102
117,425	Feb. 5 '40	80/-	80/-	East Wight Cons. 5 p.c. ...	85—90
25,000	June 19	2½	2½	Guildford 4½ p.c. Red. Deb. ...	100—105
156,600	Feb. 14	50/-	50/-	Hampron C't, 5 p.c. Cons. Ord.	95—100
18,000	Dec. 29 '41	3½	3½	Malta & Med'n., 7 p.c. 1st Pref.	30—40
10,845	June 30 '41	37/6	37/6	Do. 7½ p.c. 2nd Pref.	30—40
50,000	Feb. 21	52/3	52/3	Mid. South. Util., 'A' Cons. 5 p.c.	105—110
70,380	June 19	2½	2½	Newport (Mon.), 5 p.c. Deb...	115—120
65,000	May 8	2½	2½	North Middlesex, 5 p.c. Pref....	105—110
70,000	March 13	2½	2½	Plymouth & Stone., 5 p.c. Deb.	115—120
76,501	June 19	2	2	Reading, 4 p.c. Perp. Deb. ...	95—100
74,777	March 31	2	2	Romford, 4 p.c. Debs. (Reg.) ...	97—102
21,000	June 12	2½	2½	Slough, 5 p.c. Perp. Deb. ...	117—122
211,740	,,	2½	2½	Southampton, 5 p.c. Red. Deb.	105—110
363,575	July 3	2½	2½	Tottenham, 5 p.c. Reg. Red. Mt.	98—102
202,019	April 17	77/-	75/-	Tunbridge Wells, 4 p.c. Scale ...	125—130
135,257	June 12	2½	2½	Uxbridge &c., 5 p.c. Perp. Deb.	120—125

PROVINCIAL EXCHANGES

					Quotations July 21
804,948	Feb. 28	2½	2½	Bath Cons.	114—116
122,577	Feb. 21	—	—	Blyth 5 p.c. Ord.	120—122
1,667,250	July 17	2½	2½	Bristol, 5 p.c. max.	119—121
120,420	June 12	2	2	Do. 1st 4 p.c. Deb.	100—100
415,250	,,	2	2	Do. 2nd 4 p.c. Deb.	100—101
328,790	,,	2½	2½	Do. 5 p.c. Deb.	121—123
157,150	Jan. 31	2½	3½	Chester 5 p.c. Ord.	98—102
92,500	June 12	2	2	Do. 4 p.c. Pref.	80—82
36,430	,,	1½	1½	Do. 3½ p.c. Deb.	86—90
41,890	,,	2	2	Do. 4 p.c. Red. Deb. ...	100—102
542,270	Feb. 14	3	4½	Derby Cons.	127—132
55,000	Dec. 13	2	2	Do. 4 p.c. Deb.	95—100
40,000	Feb. 21	5½	5½	Exeter 10 p.c.	185—195
10,000	March 27	5	5	Great Grimsby 'A' Ord. ...	160—170
6,500	,,	5	5	Do. 'B' Ord. ...	160—170
79,000	,,	5	5	Do. 'C' Ord. ...	160—170
732,000	Feb. 21	2	2	Hartlepool G. & W. Cn. & New	92—93
2,167,410	Feb. 21	2½	2½	Liverpool 5 p.c. Ord.	114—115
490,681	June 19	1¾	1¾	Do. 3½ p.c. Red. Deb. Stk.	95—100
245,500	,,	2	2	Do. 4 p.c. Red. Deb. Stk.	101—102
306,083	,,	2	2	Do. 4 p.c. Deb.	101½—103½
680,000	,,	2½	2½	Do. 5 p.c. Red. Stk. ...	104—109
20,000	Dec. 21	2½	2½	Long Eaton 5 p.c. Pref.	9—11
80,000	,,	2½	2½	Do. 5 p.c. Deb.	* 105—110
2,430,267	Feb. 7	2½	2½	Newcastle and Gateshead Con.	25/6—26/-
682,856	,,	2	2	Do. 4 p.c. Pref.	100—102
776,706	July 3	1¾	1¾	Do. 3½ p.c. Deb.	99½—101½
250,000	,,	1¾	1¾	Do. 3½ p.c. Red. Deb. ...	98½—100½
73,186	May 1	2	2	Do. 4 p.c. Red. Deb. ...	99—101
106,280	Feb. 7	5	5	Preston 'A' 10 p.c.	170—175
188,219	,,	3½	3½	Do. 'B' 7 p.c.	132—135
1,806,339	Feb. 28	3½	3½	Sheffield Cons.	145—147
95,000	July 3	2	2	Do. 4 p.c. Deb.	98—100
332,351	Feb. 7	—	—	Sunderland 6 p.c. max. ...	112—114
192,150	Feb. 7	2½	2½	Weston-super-Mare Cons. ...	113—112½
64,338	July 3	2	2	Do. 4 p.c. Deb.	99—101
33,340	,,	3½	3½	Do. 7½ p.c. Deb.	145—150

a —The quotation is per £1 of Stock. * Ex. div. † For year. ‡ Paid free of income-tax.

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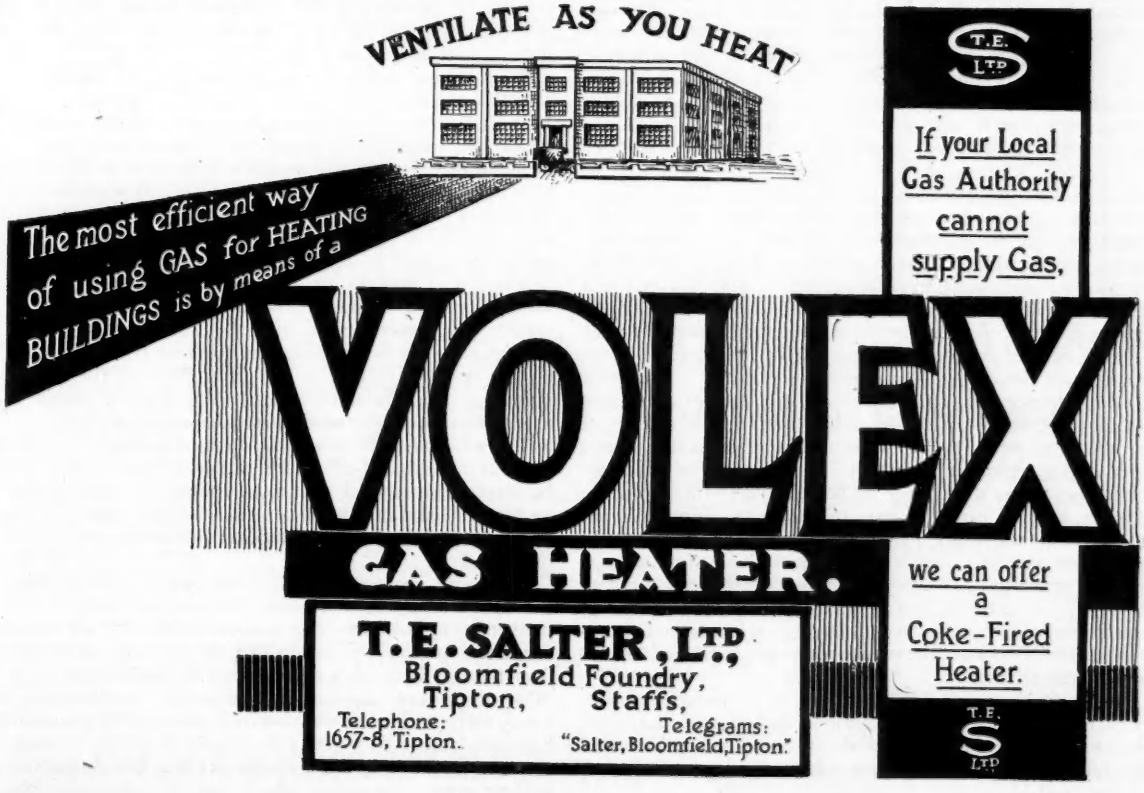
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